Sustainable Design of bioactive composites based on poly(L,L-lactide) for osseointegration: from the extrusion to plasma treatments

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Calcium phosphate-based materials (mainly hydroxyapatite, HA) have been widely used in bone-regenerative medicine due to their ability to induce bone formation. Despite the osteoconductive properties, the brittle, fragile, and inherent hardness of HA induces difficulty in the processing and proper shaping of implants, particularly in patients with extensive bone trauma, disease, and/or advanced age. Furthermore, HA friability and poor strength often limit its use in load-bearing applications. To overcome these limitations, HA micro- and nanoparticles were combined with different polymers to produce organic–inorganic composites for bone-reconstructive applications. (1,2) This combination allows ease of processing and shaping as well as mechanical integrity preservation for the desired period.

Among the used polymers, poly(lactic acid) (PLA), a biocompatible and biodegradable polyester (3,4) with a controllable degradation rate in vivo through the hydrolysis of ester bonds, (5) was extensively studied in HA biocomposites. The main challenge for the development of these materials is to achieve the good dispersion of the nano-filler with an interfacial bonding sufficient to transfer the load from the matrix to the filler, requiring some modification of the interface, particularly between the hydrophobic PLA and the hydrophilic HAp particles.

This lecture aims to present different approaches to improve the interfacial bonding between hydroxyapatite particles (HAs) and polylactide (PLA) in order to enhance the mechanical performance and biocompatibility of bone implants based on HA/PLA. Three different ways were investigated from the non-covalent stabilization by the use of PEG-b-PLA surfactant to covalent modification by grafting polymerization of lactide and plasma polymerization of acetylene. The composites are prepared by the solvent-free extrusion process. We succeeded in all cases to stabilize the interface inducing a good dispersion of the filler leading to an increase of mechanical properties and especially for the plasma-polymerized functionalized particles, resulting in a full device that is of high interest for clinical use.

References

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